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DISTRIBUTION OF FREE AND UNLIBERATED SPHALERITE, CHALCOPYRITE AND GALENA IN CONCENTRATES AND TAILINGS FROM THE MILL OF BRUNSWICK MINING AND SMELTING CORPORATION LTD.

MICHAEL R. HUGHSON AND WILLIAM PETRUK

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DISTRIBUTIONS OF FREE AND UNLIBERATED SPHALERITE, CHALCOPYRITE AND GALENA IN CONCENTRATES AND TAILINGS FROM THE MILL OF BRUNSWICK MINING AND SMELTING CORP. LTD.

by

Michael R. Hughson* and William Petruk**

ABSTRACT

Three suites of samples were obtained from the concentrator of Brunswick Mining and Smelting Corp. Ltd. over a two-year period to characterize the nature of the sphalerite, galena and chalcopyrite in the mill feed, in the zinc, lead and copper concentrates and in the plant tailings. The degree of liberation of each mineral and the size distribution of the free and unliberated mineral grains were determined using a Quantimet 720 image analyzer. These results were treated by the MATBAL 3 program to obtain a materials balance by appropriately adjusting the analyzed values. Generally, the required adjustments were negligible.

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RÉPARTITION DE LA SPHALÉRITE, DE LA CHALCOPYRITE ET DE LA GALÈNE, LIBRES ET NON LIBÉRÉES, DANS LES CONCENTRÉS ET LES RÉSIDUS DE L'USINE DE BRUNSWICK MINING AND SMELTING CORP. LTD.

par

Michael R. Hughson* et William Petruk**

RÉSUMÉ

Trois séries d'échantillons ont été obtenues au moyen du concentrateur de Brunswick Mining and Smelting Corp. Ltd., durant une période de deux ans, pour caractériser la nature de la sphalérite, de la galène et de la chalcopyrite dans les minerais d'alimentation, dans les concentrés de zinc, de plomb et de cuivre et dans les résidus de l'usine. Le degré de libération de chaque minéral et la répartition dimensionnelle des grains libres et de ceux non libérés ont été déterminés au moyen d'un analyseur d'image Quantimet 720. Ces résultats ont été traités par le programme MATBAL 3 pour obtenir un bilan minéral en réglant comme il faut les valeurs analysées. En général, les réglages requis étaient négligeables.

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INTRODUCTION

Three suites of samples of concentrates and tailings from the concentrator of Brunswick Mining and Smelting Corp Ltd. (BMS) were studied to characterize the sphalerite, galena and chalcopyrite and to establish the proportions of free and unliberated grains that are generally recovered in each concentrate and lost in the tailings. The suites were collected in August 1977, September 1977 and August 1979. The degree of liberation and size distributions of the free and unliberated grains were determined for sphalerite, galena and chalcopyrite in the August 1979 and September 1977 samples and for only sphalerite in the August 1977 samples using a Quantimet 720 image analyzer. Material balance computations were performed using the MATBAL 2 (1) and MATBAL 3 (2) programs to obtain the weight per cent of material in each product. A balance was also obtained for the degree of liberation and size distribution of the mineral grains in the 1979 and 1977 samples using the MATBAL 3 program. Some data for the September 1977 samples have been reported previously by Petruk and Schnarr (3).

CHEMICAL ANALYSES, RECOVERIES AND MATERIALS BALANCE

Analyses for zinc, lead and copper were provided by BMS for the three suites. The data for the 1979 and August 1977 samples were computed by the MATBAL 3 program to obtain the weight per cent material in each product, metal recoveries and assay adjustments required in order to obtain a balance (Tables 1 and 2). Adjustments are required because a balance cannot be obtained using observed data, which incorporate sampling and analytical errors, and fluctuations in the concentrator. Values for the September 1977 samples were treated with the MATBAL 2 program (2) and reported by Petruk and Schnarr (3). They are, however, reproduced in Table 1 since the 1977 samples form part of this study.

MINERAL LIBERATION AND SIZE DISTRIBUTION

The amount of sphalerite, galena and chalcopyrite present as free grains was determined using a Quantimet 720 image analyzer. These data were adjusted to best fit for a materials balance by using the MATBAL 3 program so that the amount of either free or unliberated mineral grains entering each cell is equal to the amount discharged. This was accomplished by converting the weight per cent free and unliberated sphalerite, galena and chalcopyrite to weight per cent zinc, lead and copper, respectively in each sample and computing materials balance using the MATBAL 3 program. The balanced assay data were then reconverted to the weight per cent of each mineral as free and unliberated grains (Table 3).

The size distribution of the free and unliberated grains was determined using the image analyzer. The size of free grains was measured as the surface area of each grain observed on polished sections, and the size of unliberated grains as the surface area of each grain of the specific mineral in the host middling particles. A materials balance analysis was performed using MATBAL 3 to obtain a balance of the size distribution data by converting the amount of mineral present as either free or unliberated grains to amounts contributing to the zinc, and copper assays and computing the results in the same manner as for the materials balance of mineral liberations. The adjustments required to obtain a balance were negligible, therefore, only the balanced data are included in this report (Tables 4 to 9 and Fig. 1, 2 and 3). Figures 1, 2 and 3 were plotted by computer according to a program written by W.S. Bowman, by inputting the data from Tables 4 to 9 (4).

The recoveries of free and unliberated grains at each size range were calculated by the materials balance program. They are given in Tables 10 to 15 and in Figures 4 to 9. Figures 4 to 6 are plotted so that total amount of mineral (e.g., free sphalerite) in each size range (e.g.,

270-400 mesh ~ 52-37 μm) in all concentrates plus tailings is 100%. Figures 7 to 9 are plotted so that total amount of free plus unliberated mineral of all sizes in all concentrates plus tailings is 100% (Tables 16-21).

DISCUSSION

The following characteristics were found for ore, concentrates and tailings.

SPHALERITE

The ore contains from 6.8 to 10.5% zinc as sphalerite. Of the sphalerite, 61 to 65 wt % is present in the mill feed as free grains. These grains are generally smaller than 100 μm in diameter and from 1 to 11% is as free grains that are smaller than 3.3 μm. Most of the unliberated sphalerite grains are from 15 to 74 μm in diameter although 5 to 16% of the sphalerite is present as inclusions that are smaller than 13 μm.

Recovery of sphalerite in the primary plus secondary zinc concentrates varies from 78.5 to 80.1 wt %. From 68 to 72% of the sphalerite in zinc concentrate is as free grains, and this is equivalent to 52.2 to 55.5% of the sphalerite in the ore. The free sphalerite grains in the zinc concentrate are generally smaller than 100 μm and from 0.4 to 9.8% of the sphalerite in the ore is in the zinc concentrate as minus 3.3 μm free grains.

From 19.8 to 24.5% of the sphalerite in the ore is recovered in the zinc concentrate as unliberated grains. The unliberated sphalerite tends to be as grains larger than 15 μm, but 2 to 7.5% of the sphalerite in the ore is in the zinc concentrate as minus 13 μm unliberated grains.

The losses of sphalerite to the plant tailings range from 9.7 to 14.2%. From 20 to 33% of the sphalerite in the tailings is as free grains. The maximum size of these grains is 37 μm for the August 1977 samples, and greater than 74 μm for the August 1979 samples. Unliberated sphalerite is also coarser in the August 1979 suite, i.e., 5% of the sphalerite in the tailings is as unliberated grains larger than 74 μm for August 1977 and 25% for August 1979. By contrast 58% of the unliberated sphalerite in the plant tailings is smaller than 13 μm for the August 1977 sample and 21% for August 1979.

GALENA

The ore contains from 3.3 to 4.5 wt % lead as galena and from 36 to 39% is as free grains in the mill feed. Most of the free galena grains are smaller than 37 μm and from 2 to 23% of the galena is in grains that are smaller than 3.3 μm. Most of the unliberated galena grains are smaller than 52 μm and from 3 to 30% of the unliberated galena is as grains that are smaller than 3.3 μm.

Galena recovery in the lead concentrate varies from 56 to 62% and the lead concentrate contains 50% of the galena as free grains. The free galena grains in the lead concentrate are smaller than 37 μm and from 2 to 18% of the free galena in the lead concentrate is as grains that are smaller than 3.3 μm. Unliberated grains of galena are slightly larger than the free galena grains, ranging up to 52 μm but only 1 to 15% of the unliberated galena in the lead concentrate is as unliberated grains that are smaller than 3.3 μm.

The percentage of galena lost to the plant tailings varies from 23.6 to 30.7%. The percentage of the galena in the tailing that is present as free grains varies from 7% for September 1977 and 52% for August 1979. Maximum size of the free galena grains in the former sample is about 18 μm and in the latter, 37 μm. The unliberated galena grains in the September 1977 plant tailings are very small with 49% being smaller than 3.3 μm. By contrast the galena grains in the August 1979 plant tailings are larger with 73% larger than 9.4 μm.

CHALCOPYRITE

The ore contains from 0.27 to 0.60 wt % copper, and from 52 to 61% of it occurs as free chalcopyrite grains in the mill feed. The maximum size of the free grains is 74 μm and from 1 to 14% of the free chalcopyrite is as grains smaller than 3.3 μm. The largest unliberated chalcopyrite grains are about 74 μm for the September 1977

samples but at 34 μm are smaller for August 1979 samples.

The chalcopyrite recovery in the copper concentrate varies from 25.3 to 36.8 wt %, and in the lead concentrate from 20.5 to 24.2 wt %. The proportion of chalcopyrite as free grains varies from 81 to 94% in the copper concentrate and is 74% in the lead concentrate. Most of the free chalcopyrite grains for the September 1977 concentrate are very small (84% minus 13 μm) whereas for August 1979 they are larger (79% minus 37 μm).

The proportion of chalcopyrite lost to the tailings varies from 33.4 to 39.6% of chalcopyrite in the ore. Of these values 23 to 28% are as free chalcopyrite grains. The free chalcopyrite grains are relatively large with more than 80% larger than 9.4 μm. Most of the chalcopyrite (more than 70%) in the tailings is as unliberated grains. These unliberated grains are of all sizes.

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Table 1 - Chemical analyses, weight per cent of material, and metal recoveries

Product	Wt % material	Assay (wt %) Zn	Pb	Cu	Recoveries (%) Zn	Pb	Cu
August 1977:							
Mill feed	100.00	6.75	3.25	0.43	100.00	100.00	100.00
Pb conc.	5.37	8.45	34.02	1.62	6.73	56.27	20.50
Cu conc.	0.72	5.61	7.61	21.67	0.58	1.69	36.77
Bulk conc.	0.80	32.64	21.38	0.81	3.85	5.27	1.53
Zn conc.	9.72	51.78	2.07	0.34	74.65	6.20	7.78
Plant tailings	83.39	1.15	1.19	0.17	14.23	30.57	33.42
September 1977:							
Mill feed	100.00	10.46	4.47	0.27	100.00	100.00	100.00
Pb conc.	8.00	8.81	38.26	0.71	6.74	61.27	21.13
Cu conc.	0.42	2.33	15.52	16.10	0.09	1.46	25.28
Bulk conc.	0.95	36.92	20.56	0.74	3.35	4.37	2.61
Zn conc.	15.90	50.29	2.33	0.15	76.47	8.27	9.09
2nd Zinc conc.	0.92	41.01	5.17	0.66	3.61	1.07	2.27
Plant tailings	73.82	1.38	1.43	0.14	9.74	23.56	39.62
August 1979:							
Mill feed	100.00	10.08	3.70	0.28	100.00	100.00	100.00
Pb conc.	7.20	7.80	30.33	0.93	5.61	59.45	24.20
Cu conc.	0.35	2.20	7.58	20.56	0.08	0.71	25.66
Bulk conc.	0.99	31.75	21.09	0.63	3.12	5.64	2.23
Zn conc.	14.27	51.74	2.36	0.23	73.23	9.08	11.76
2nd Zn conc.	1.03	51.80	2.92	0.24	5.28	0.81	0.88
Plant tailings	76.10	1.68	1.18	0.13	12.68	24.31	35.27

Table 2 - Adjustments of assay values to obtain materials balance

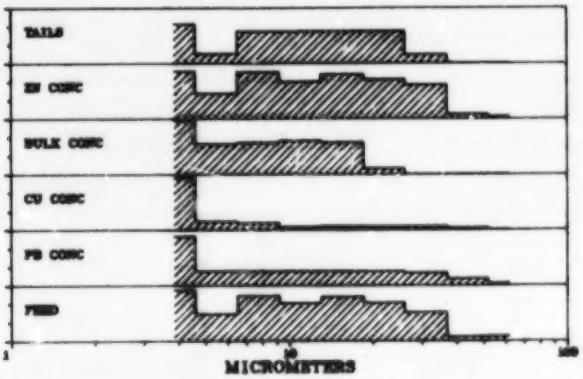
	August 1979 obs.	bal.	September 1977 obs.	bal.	August 1977 obs.	bal.
Zinc:						
Mill feed	9.24	10.08	9.03	10.46	6.60	6.75
Pb conc.	7.84	7.80	8.93	8.81	8.46	8.45
Cu conc.	2.20	2.20	2.33	2.33	5.61	5.61
Bulk conc.	31.85	31.75	31.15	36.92	32.69	32.64
Zn conc.	52.02	51.74	53.62	50.29	52.23	51.78
2nd Zn conc.	51.80	51.80	40.66	41.02	-	-
Plant tailings	1.68	1.68	1.35	1.38	1.15	1.15
Lead:						
Mill feed	3.72	3.70	4.49	4.47	3.56	3.25
Pb conc.	30.26	30.33	34.17	34.26	32.63	34.02
Cu conc.	7.58	7.58	15.52	15.52	7.60	7.61
Bulk conc.	21.09	21.09	20.56	20.56	21.29	21.38
Zn conc.	2.35	2.36	2.24	2.33	2.06	2.07
2nd Zn conc.	2.92	2.92	5.11	5.17	-	-
Plant tailings	1.18	1.18	1.16	1.43	1.16	1.16
Copper:						
Mill feed	0.27	0.28	0.18	0.27	0.60	0.43
Pb conc.	0.94	0.93	0.87	0.71	1.56	1.62
Cu conc.	20.76	20.576	21.18	16.10	20.25	21.67
Bulk conc.	0.63	0.63	0.75	0.74	0.81	0.81
Zn conc.	0.23	0.23	0.16	0.15	0.34	0.34
2nd Zn conc.	0.24	0.24	0.66	0.66	-	-
Plant tailings	0.13	0.13	0.15	0.14	0.17	0.17

Table 3 - Weight per cent of free sphalerite, galena, and chalcopyrite

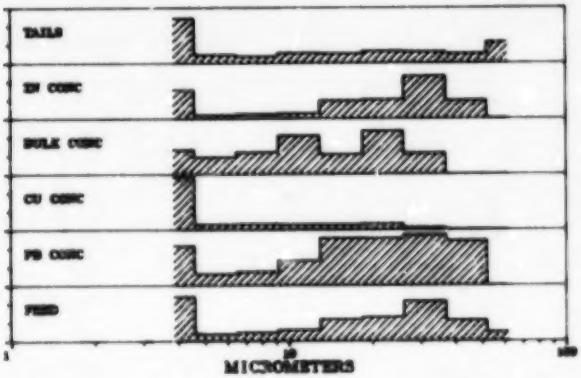
	August 1979 obs.	bal.	September 1977 obs.	bal.	August 1977 obs.	bal.
Sphalerite						
Mill feed	47	61	61	65	61*	61
Pb conc.	42	41	46	46	20	20
Cu conc.	47	47	28	28	47	47
Bulk conc.	52	52	50	50	52	52
Zn conc.	74	68	85	72	71	72
2nd Zn conc.	70	70	63	63	-	-
Plant tailings	33	33	24	23	20	20

*obs = 36 but MATBAL 3 program would not run until observed value near 60.

Galena						
Mill feed	46	49	37	36	-	-
Pb conc.	51	50	50	51	-	-
Cu conc.	21	21	90	90	-	-
Bulk conc.	44	44	5	5	-	-
Zn conc.	50	47	15	15	-	-
2nd Zn conc.	<1	<1	16	16	-	-
Plant tailings	55	52	8	7	-	-
Chalcopyrite						
Mill feed	54	61	56	52	-	-
Pb conc.	75	74	76	74	-	-
Cu conc.	94	94	90	81	-	-
Bulk conc.	63	62	72	72	-	-
Zn conc.	70	67	51	52	-	-
2nd Zn conc.	67	67	32	32	-	-
Plant tailings	31	28	23	23	-	-



LIBERATED SPHALERITE, AUGUST,1977



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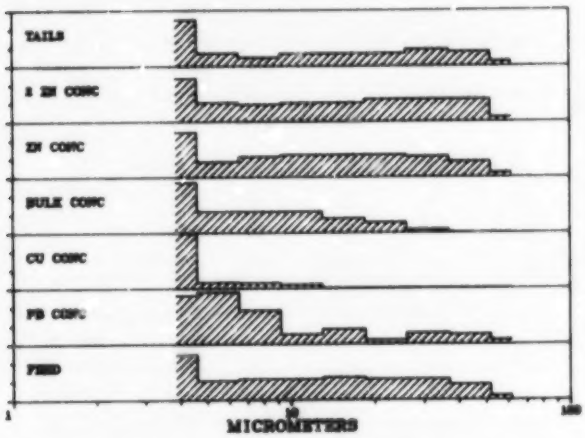

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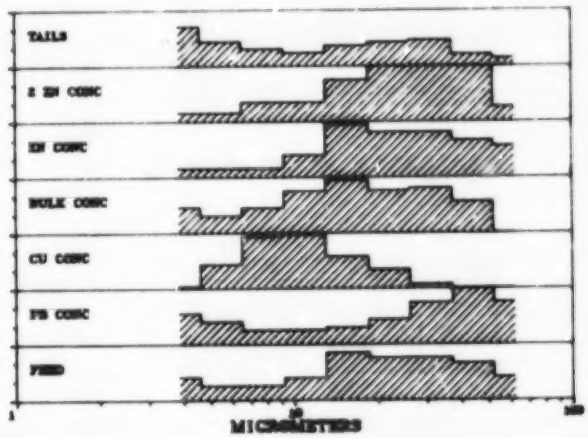

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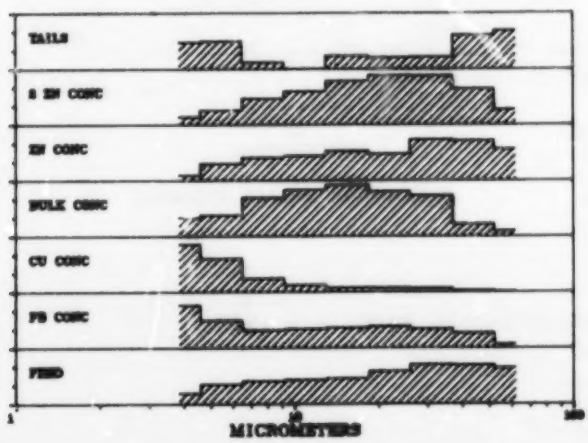

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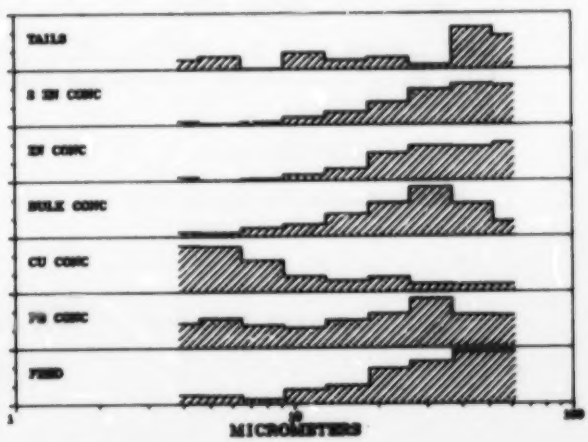


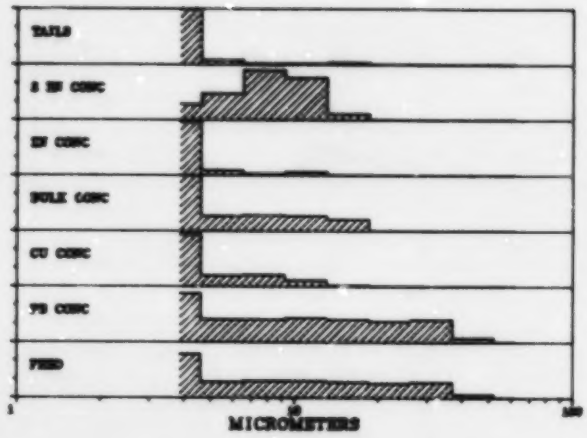
UNLIBERATED SPHALERITE, AUGUST,1979

Fig. 1 - Size distributions of free and unliberated sphalerite.

Table 4 - Balanced size distributions*, free sphalerite

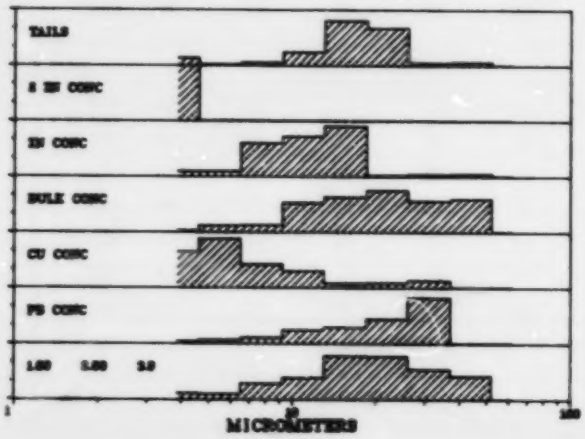
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>104
August 1977											
Mill feed	11	18	27	44	57	74	87	97	98	100	
Pb conc.	26	35	45	55	65	75	85	94	99	100	
Cu conc.	50	65	75	83	86	90	94	98	100		
Bulk conc.	15	29	45	62	80	97	100				
Zn conc.	10	17	26	43	56	72	86	98	99	100	
2nd Zn conc.											
Plant tailings	13	21	26	43	61	78	96	100			
September 1977											
Mill feed	17	24	34	45	56	68	79	90	98	100	
Pb conc.	8	26	54	72	77	85	87	93	98	100	
Cu conc.	69	80	88	95	100						
Bulk conc.	23	36	51	66	81	91	98	100			
Zn conc.	17	24	32	43	55	67	79	90	98	100	
2nd Zn conc.	14	23	33	42	52	62	74	86	98	100	
Plant tailings	24	33	42	48	57	66	75	87	97	100	
August 1979											
Mill feed	1	4	11	19	28	37	49	63	76	87	100
Pb conc.	4	23	38	47	57	68	80	90	97	100	
Cu conc.	6	43	72	84	90	93	96	99	100		
Bulk conc.	1	7	14	28	45	63	79	93	98	99	100
Zn conc.	1	2	8	16	25	36	45	60	74	85	100
2nd Zn conc.	1	3	8	17	29	45	63	80	93	98	100
Plant tailings	3	14	29	32	32	40	46	52	70	91	100

*Size distributions as per cent smaller than, with respect to size given.

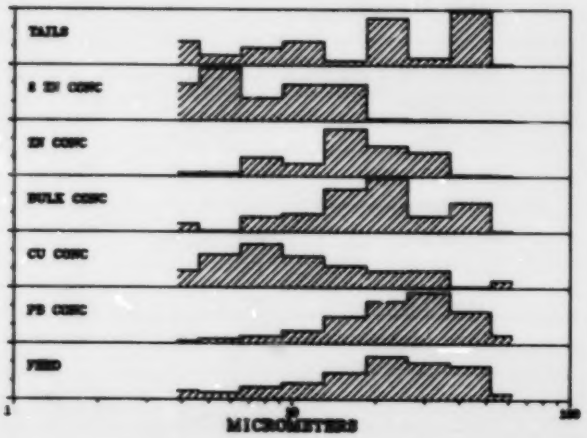


LIBERATED GALENA, SEPTEMBER,1977

UNLIBERATED GALENA, SEPTEMBER,1977



LIBERATED GALENA, AUGUST,1979



UNLIBERATED GALENA, AUGUST,1979

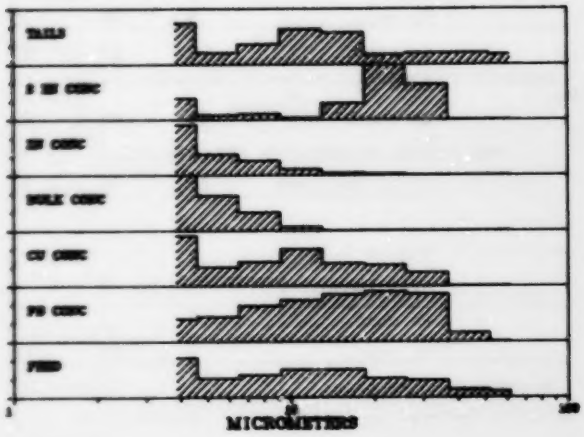
Fig. 2 - Size distributions of free and unliberated galena.

Table 5 - Balanced size distributions*, unliberated sphalerite

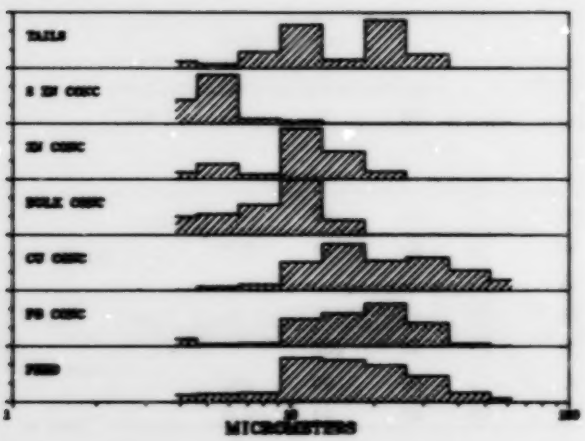
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
August 1977											
Mill feed	18	24	27	32	38	49	62	84	94	99	100
Pb conc.	10	14	18	23	32	49	66	84	100		
Cu conc.	60	66	72	79	85	91	98	100			
Bulk conc.	5	13	22	34	55	66	89	100			
Zn conc.	18	21	23	26	30	43	57	87	100		
2nd Zn conc.											
Plant tailings	22	32	38	42	50	56	65	73	80	95	100
September 1977											
Mill feed	3	8	13	18	26	43	58	73	86	94	100
Pb conc.	6	11	19	24	29	35	44	59	79	94	100
Cu conc.	1	1	14	42	71	88	98	100			
Bulk conc.	6	9	15	24	39	58	73	89	100		
Zn conc.	1	3	6	9	17	36	52	68	81	92	100
2nd Zn conc.	2	3	6	13	20	35	55	75	95	100	
Plant tailings	7	21	34	43	50	61	74	88	94	98	100
August 1979											
Mill feed	1	3	6	7	13	19	32	47	66	84	100
Pb conc.	2	9	20	28	35	45	57	75	87	98	100
Cu conc.	4	25	49	66	74	80	88	92	96	100	
Bulk conc.	1	2	4	9	16	28	46	72	90	97	100
Zn conc.	2	2	2	3	6	12	27	46	64	84	100
2nd Zn conc.	1	2	2	4	8	15	27	46	68	89	100
Plant tailings	1	5	12	12	21	26	32	34	57	75	100

*Size distributions as per cent smaller than, with respect to size given.

LIBERATED CHALCOPYRITE, SEPTEMBER,1977



UNLIBERATED CHALCOPYRITE, SEPTEMBER,1977



LIBERATED CHALCOPYRITE, AUGUST,1979

UNLIBERATED CHALCOPYRITE, AUGUST,1979

Fig. 3 - Size distributions of free and unliberated chalcopyrite.

Table 6 - Balanced size distributions*, free galena

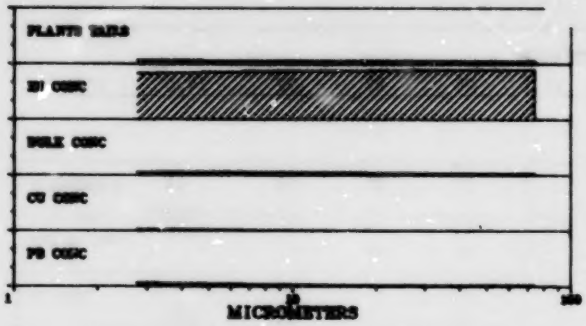
Flotation cells	Micrometres								
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	>37
September 1977									
Mill feed	23	31	42	54	66	77	87	98	100
Pb conc.	18	26	38	50	63	75	86	98	100
Cu conc.	52	65	78	92	99	100			
Bulk conc.	38	50	63	77	90	100			
Zn conc.	81	86	93	95	100				
2nd Zn conc.	5	11	30	66	96	100			
Plant tailings	84	89	95	96	97	100			
August 1979									
Mill feed	2	3	6	14	26	50	72	87	100
Pb conc.	2	2	5	10	22	37	59	100	
Cu conc.	4	27	61	77	89	92	95	100	
Bulk conc.	1	1	4	8	24	43	65	82	100
Zn conc.	3	3	7	31	60	96	97	98	100
2nd Zn conc.	82	100							
Plant tailings	5	7	7	10	22	62	95	97	100

*Size distributions as per cent smaller than, with respect to size given.

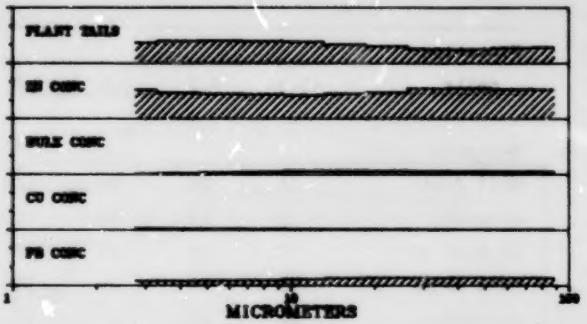
Table 7 - Balanced size distributions*, unliberated galena

Flotation cells	Micrometres									
	<3.3	4.7	6.6	9.4	13.2	18.6	26	37	52	>52
September 1977										
Mill feed	30	36	43	51	59	71	86	98	100	
Pb conc.	15	20	25	33	40	56	80	98	100	
Cu conc.	52	65	78	92	99	100				
Bulk conc.	27	44	58	72	86	100				
Zn conc.	47	55	62	69	77	85	92	100		
2nd Zn conc.	13	20	33	47	61	76	90	99	100	
Plant tailings	49	56	64	71	78	85	92	99	100	
August 1979										
Mill feed	3	4	8	14	23	37	60	80	97	100
Pb conc.	1	1	3	7	14	28	51	78	96	100
Cu conc.	2	9	26	50	67	78	87	96	96	100
Bulk conc.	4	4	5	13	23	46	75	84	100	
Zn conc.	2	2	4	18	26	60	82	98	99	100
2nd Zn conc.	7	20	48	60	79	99	100			
Plant tailings	6	12	17	27	39	41	67	71	99	100

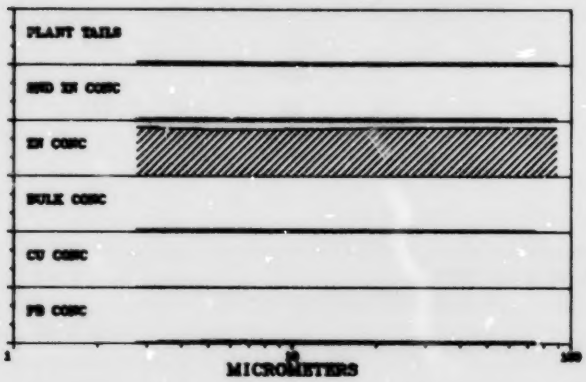
*Size distribution as per cent smaller than, with respect to size given.



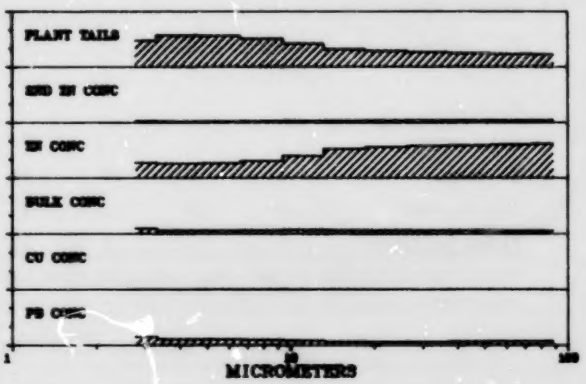
FREE SPHALERITE, AUGUST,1977



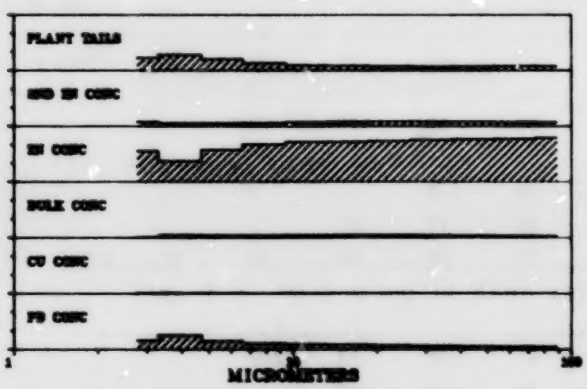
UNLIBERATED SPHALERITE, AUGUST,1977



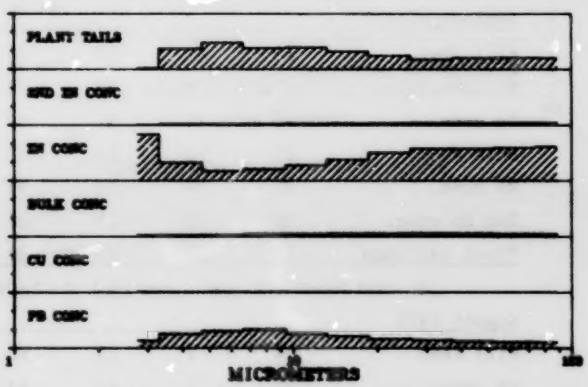
FREE SPHALERITE, SEPTEMBER,1977



UNLIBERATED SPHALERITE, SEPTEMBER,1977



FREE SPHALERITE, AUGUST,1978



UNLIBERATED SPHALERITE, AUGUST,1978

Fig. 4 - Recoveries of free and unliberated sphalerite. Total amount of free (or of unliberated) sphalerite in each size range of Tyler series ($\sqrt{2}$) concentrates plus tailings is 100%. For example the sum for free sphalerite that is 37 to 52 μm in diameter in all concentrates plus tailings is 100%.

Table 8 - Balanced size distributions*, free chalcopyrite

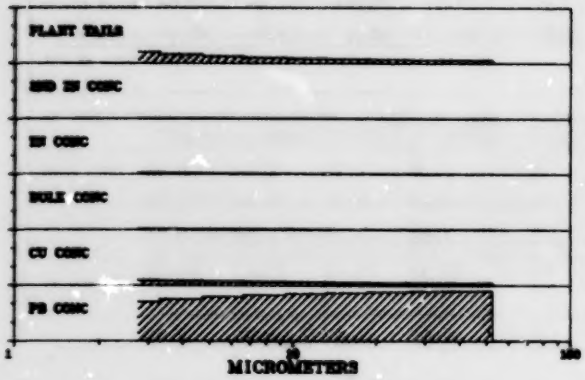
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26	37	52	74.0	>74
September 1977											
Mill feed	14	20	30	42	61	75	85	91	96	99	100
Pb conc.	9	13	24	32	43	54	65	75	85	94	100
Cu conc.	18	30	49	66	84	93	97	98	100		
bulk conc.	45	70	93	99	100						
Zn conc.	11	13	18	28	51	68	91	93	96	100	
2nd Zn conc.	19	24	36	65	84	99	100				
Plant tailings	7	10	11	18	33	50	64	76	90	100	
August 1979											
Mill feed	1	4	8	13	36	59	79	92	97	98	100
Pb conc.	2	5	6	8	28	51	82	98	100		
Cu conc.	1	1	2	5	21	50	61	70	90	95	100
Bulk conc.	3	13	28	50	90	100					
Zn conc.	1	6	20	24	69	94	100				
2nd Zn conc.	5	29	91	97	100						
Plant tailings	3	5	7	19	50	56	90	100			

*Size distribution as per cent smaller than, with respect to size given.

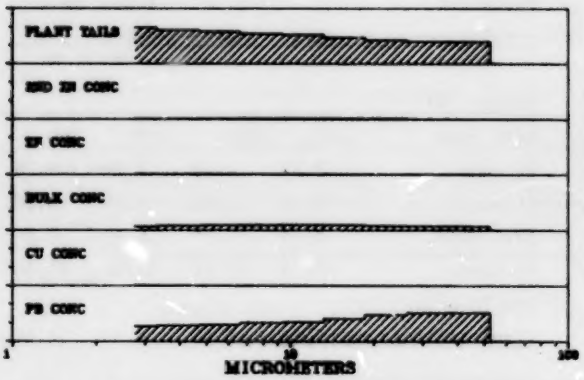
Table 9 - Balanced size distributions*, unliberated chalcopyrite

Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
September 1977											
Mill feed	15	21	31	43	58	73	83	92	96	99	100
Pb conc.	5	8	17	30	45	62	80	98	100		
Cu conc.	15	27	37	50	70	82	93	100			
Bulk conc.	25	50	81	97	100						
Zn conc.	27	54	76	91	97	99	100				
2nd Zn conc.	15	15	18	22	23	35	75	100			
Plant tailings	19	22	28	39	58	75	80	86	92	97	100
August 1979											
Mill feed	4	7	19	51	83	91	98	99	100		
Pb conc.	0	1	17	63	80	93	99	100			
Cu conc.	0	1	3	13	37	63	83	100			
Bulk conc.	3	12	35	56	88	100					
Zn conc.	19	23	54	87	98	100					
2nd Zn conc.	8	35	100								
Plant tailings	3	6	14	46	72	91	98	99	100		

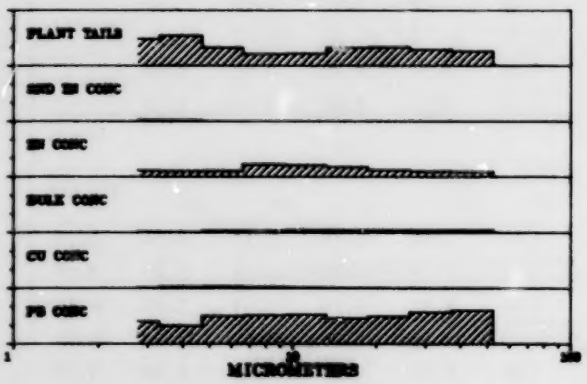
*Size distribution as per cent smaller than, with respect to size given.



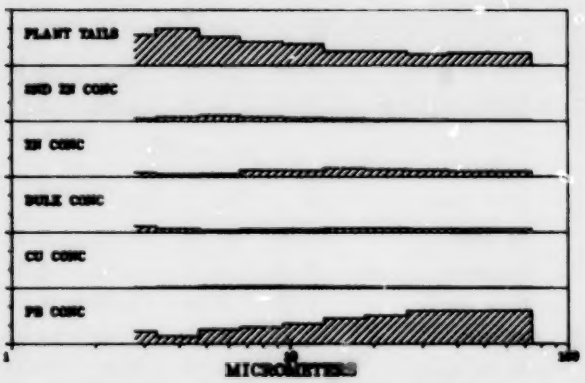
FREE GALENA, SEPTEMBER,1977



UNLIBERATED GALENA, SEPTEMBER,1977



FREE GALENA, AUGUST,1978

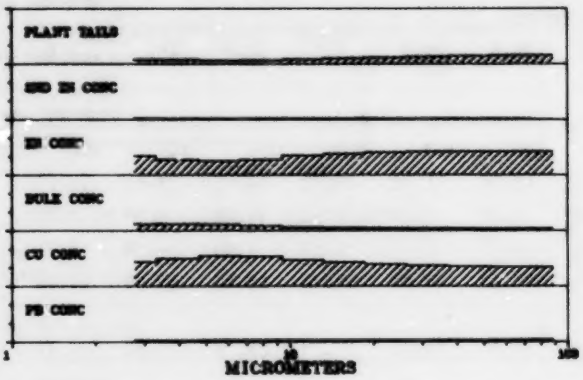


UNLIBERATED GALENA, AUGUST,1978

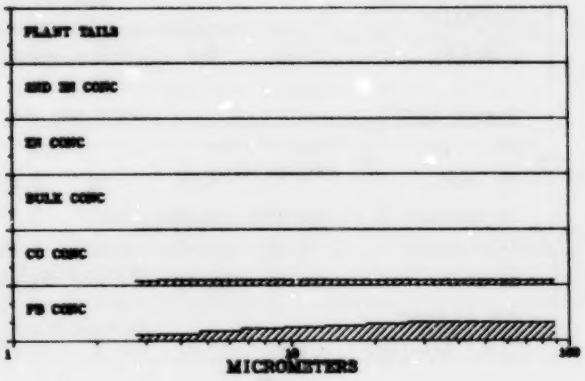
Fig. 5 - Recoveries of free and unliberated galena, as in caption to Fig. 4.

Table 10 - Balanced recoveries, free sphalerite (free sphalerite = 100%)

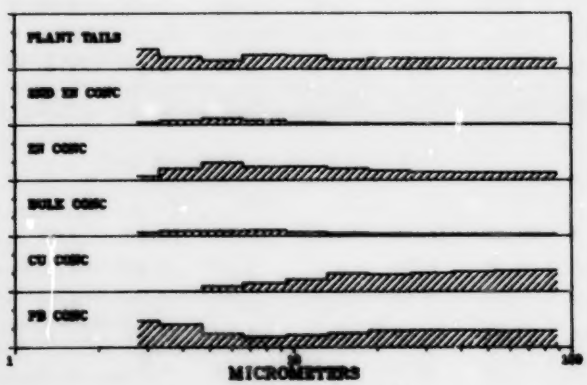
Flotation cells	Micrometres										
	<3.3	3.3-4.7	4.7-6.6	6.6-9.4	9.4-13.2	13.2-18.6	18.6-26.3	23.6-37.1	37.0-52.4	52.0-74.0	>74
August 1977											
Mill feed	100	100	100	100	100	100	100	100	100	100	
Pb conc.	5.34	4.26	3.67	2.78	2.52	2.28	2.18	2.13	2.20	2.22	
Cu conc.	2.15	1.66	1.28	0.88	0.70	0.57	0.50	0.46	0.47	0.47	
Bulk conc.	4.59	5.28	5.49	4.69	4.63	4.40	3.82	3.39	3.34	3.32	
Zn conc.	82.28	83.18	85.06	87.00	87.16	87.72	88.32	89.22	89.26	89.29	
2nd Zn conc.											
Plant tailings	5.65	5.61	4.50	4.65	4.98	5.02	5.17	4.79	4.72	4.70	
September 1977											
Mill feed	100	100	100	100	100	100	100	100	100	100	
Pb conc.	1.54	3.44	5.19	5.19	4.42	3.98	3.52	3.32	3.21	3.22	
Cu conc.	0.16	0.13	0.11	0.09	0.07	0.06	0.05	0.04	0.04	0.04	
Bulk conc.	3.57	3.85	3.93	3.84	3.76	3.47	3.22	2.90	2.66	2.60	
Zn conc.	86.96	84.51	82.92	83.75	84.92	85.85	86.58	86.92	87.08	87.11	
2nd Zn conc.	2.84	3.30	3.45	3.32	3.25	3.23	3.30	3.40	3.53	3.52	
Plant tailings	4.92	4.76	4.40	3.81	3.58	3.41	3.33	3.41	3.48	3.50	
August 1979											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	15.29	24.90	14.02	9.94	8.31	7.43	6.60	5.76	5.13	4.56	4.08
Cu conc.	0.44	0.72	0.42	0.28	0.20	0.16	0.12	0.10	0.08	0.07	0.06
Bulk conc.	0.62	4.94	3.66	4.15	4.53	4.81	4.57	4.19	3.59	3.20	2.85
Zn conc.	54.41	36.46	57.40	67.12	71.50	71.83	73.45	75.56	76.62	77.22	79.01
2n Zn conc.	7.12	4.73	4.66	5.83	6.79	7.86	8.31	8.25	7.82	7.24	6.52
Plant tailings	22.12	28.25	19.83	12.66	8.67	7.91	6.93	6.14	6.76	7.70	7.48



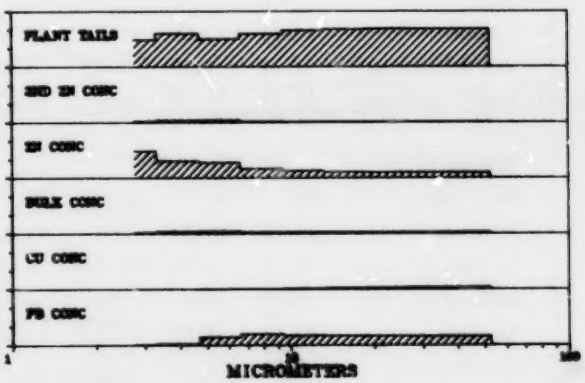
FREE CHALCOPYRITE, SEPTEMBER,1977



UNLIBERATED CHALCOPYRITE, SEPTEMBER,1977



FREE CHALCOPYRITE, AUGUST,1979

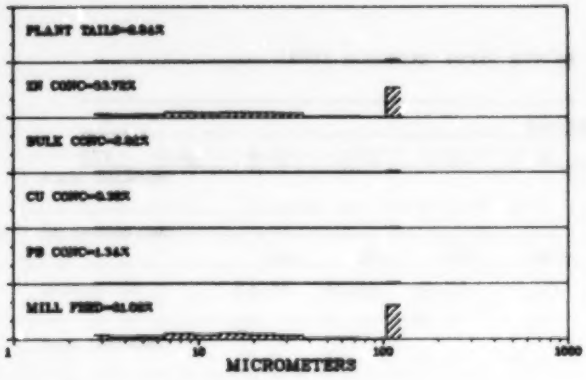


UNLIBERATED CHALCOPYRITE, AUGUST,1979

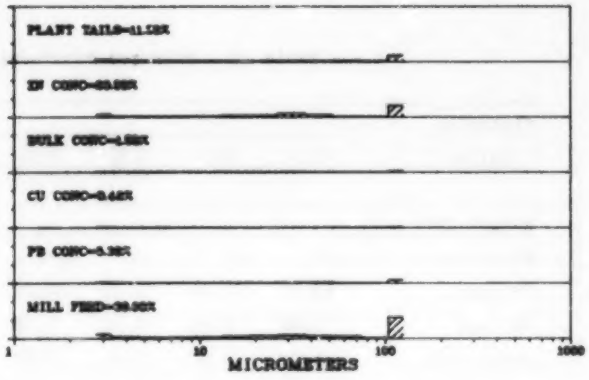
Fig. 6 - Recoveries of free and unliberated chalcopyrite, as in Fig. 4.

Table 11 - Balanced recoveries, unliberated sphalerite (unliberated sphalerite = 100%)

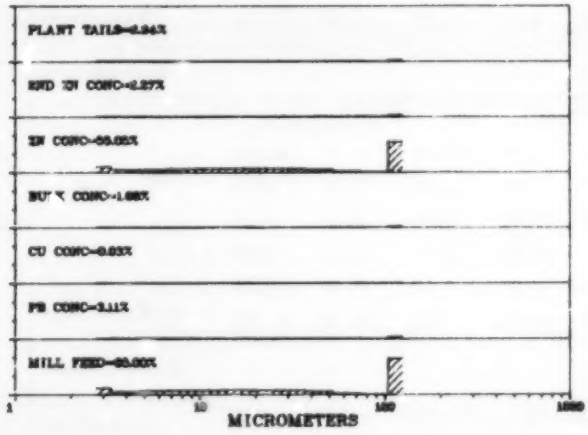
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
August 1977											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	7.71	8.36	9.16	10.05	11.63	13.54	14.42	13.73	14.45	13.83	13.63
Cu conc.	2.74	2.31	2.15	2.03	1.82	1.48	1.26	0.96	0.85	0.81	0.80
Bulk conc.	1.33	2.66	3.86	5.14	6.92	6.68	6.74	5.64	4.99	4.78	4.71
Zn conc.	51.80	46.42	44.27	43.52	41.42	45.33	47.48	54.49	55.43	52.90	52.06
2nd Zn conc.											
Plant tailings	36.41	40.27	40.55	39.25	38.21	32.96	30.10	25.18	24.27	27.65	28.79
September 1977											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	14.11	10.30	10.31	9.19	7.91	5.75	5.48	5.70	6.54	7.18	7.14
Cu conc.	0.04	0.02	0.21	0.44	0.53	0.41	0.33	0.27	0.23	0.21	0.20
Bulk conc.	9.41	5.82	5.42	6.44	7.33	6.62	6.16	5.89	5.66	5.17	4.90
Zn conc.	27.15	25.59	26.75	30.92	39.93	52.80	56.24	58.06	59.21	60.71	62.08
2nd Zn conc.	2.44	1.48	1.78	2.74	2.99	3.18	3.71	3.98	4.32	4.15	3.92
Plant tailings	46.84	56.79	55.53	50.26	41.32	31.23	28.09	26.11	24.03	22.58	21.76
August 1979											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	13.28	25.53	30.47	33.82	25.08	21.17	16.30	14.48	11.99	10.60	9.77
Cu conc.	0.37	0.89	0.92	0.98	0.65	0.46	0.30	0.22	0.16	0.13	0.12
Bulk conc.	2.28	2.91	2.91	4.92	5.04	5.88	5.89	6.31	5.49	4.75	4.43
Zn conc.	82.41	31.67	16.66	20.53	27.29	37.58	50.08	57.51	57.42	58.99	61.20
2nd Zn conc.	0.02	2.25	1.51	2.14	2.73	3.39	3.75	4.34	4.59	4.68	4.57
Plant tailings	1.63	36.78	47.51	37.62	39.21	31.52	23.68	17.14	20.35	20.84	19.91



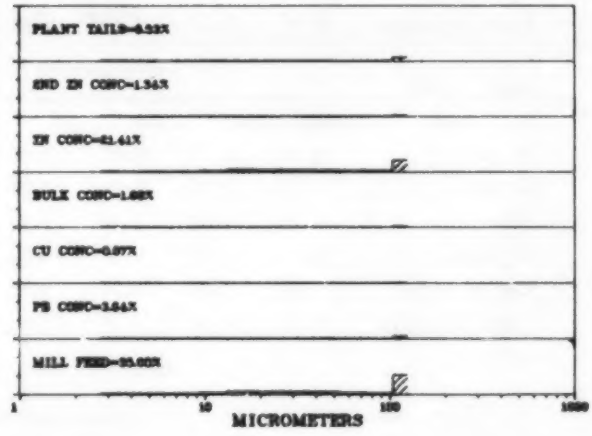
FREE SPHALERITE, AUGUST,1977



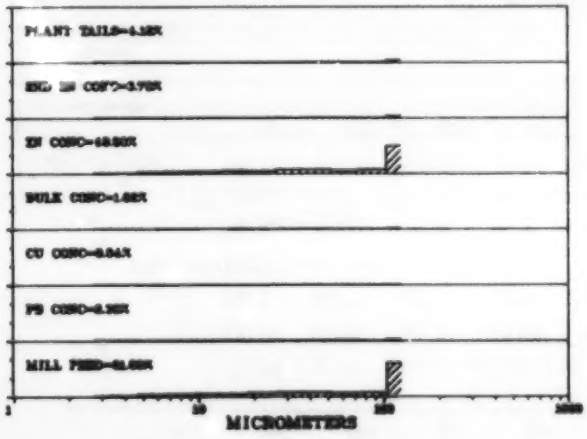
UNLIBERATED SPHALERITE, AUGUST,1977



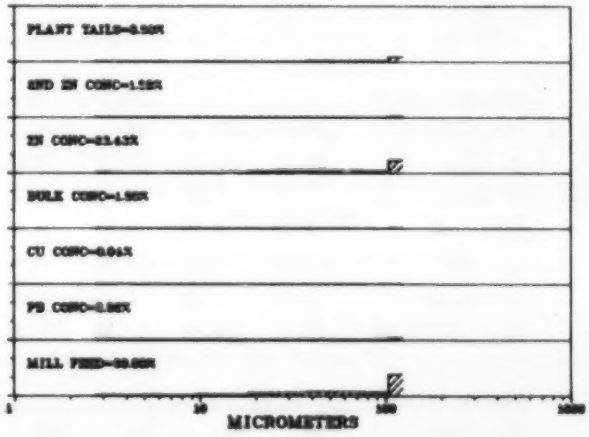
FREE SPHALERITE, SEPTEMBER,1977



UNLIBERATED SPHALERITE, SEPTEMBER,1977



FREE SPHALERITE, AUGUST,1978



UNLIBERATED SPHALERITE, AUGUST,1978

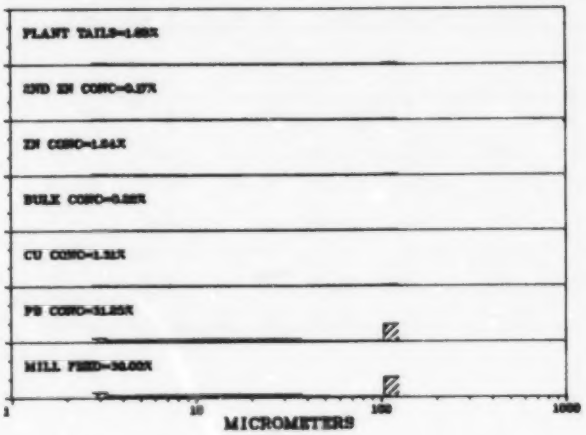
Fig. 7 - Recoveries for sphalerite-weight per cent of total free plus unliberated in each feed equals 100%. These same amounts are distributed among the concentrates and tailings. The total recovery in each product is shown at the extreme right side of each plot, and the distributions among the various sized fractions are shown across the plot.

Table 12 - Balanced recoveries, free galena (free galena = 100%)

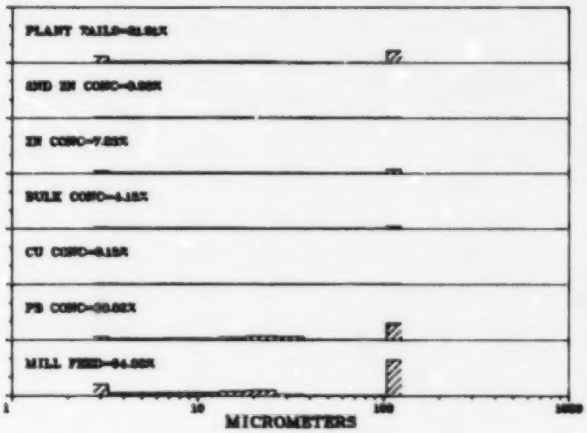
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
August 1977											
Mill feed	100	100	100	100	100	100	100	100	100		
Pb conc.	69.43	74.96	79.39	82.21	84.63	86.55	88.02	89.34	89.53		
Cu conc.	8.48	7.83	6.81	6.30	5.52	4.78	4.24	3.77	3.71		
Bulk conc.	1.03	1.00	0.92	0.88	0.84	0.80	0.71	0.63	0.62		
Zn conc.	1.52	1.19	0.94	0.75	0.64	0.55	0.49	0.44	0.43		
2nd Zn conc.	0.11	0.17	0.34	0.59	0.71	0.63	0.56	0.50	0.49		
Plant tailings	19.37	15.17	11.60	9.26	7.66	6.68	5.98	5.32	5.23		
August 1979											
Mill feed	100	100	100	100	100	100	100	100	100		
Pb conc.	39.61	31.87	49.94	51.08	52.16	45.38	49.41	56.77	60.31		
Cu conc.	0.53	2.76	3.41	2.05	1.09	0.59	0.42	0.36	0.32		
Bulk conc.	1.25	1.03	3.80	3.50	4.83	4.55	4.70	4.85	5.18		
Zn conc.	10.70	9.60	10.58	22.80	20.48	17.28	11.82	9.83	8.79		
2nd Zn conc.	1.90	1.90	0.10	0.05	0.02	0.01	0.08	0.06	0.06		
Plant tailings	47.71	54.55	32.18	20.51	21.41	32.19	33.63	28.18	25.40		

Table 13 - Balanced recoveries, unliberated galena (unliberated galena = 100%)

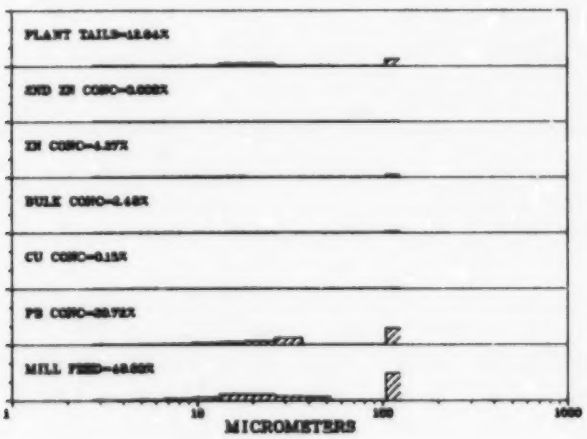
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26	37	52.4	74.0	>74
September 1977											
Mill feed	100	100	100	100	100	100	100	100	100		
Pb conc.	26.46	28.78	30.14	33.49	35.13	40.89	47.61	50.99	51.46		
Cu conc.	0.42	0.43	0.43	0.43	0.40	0.34	0.28	0.24	0.24		
Bulk conc.	6.36	8.48	9.41	9.85	10.08	9.74	8.01	7.04	6.95		
Zn conc.	1.00	0.95	0.91	0.85	0.83	0.75	0.68	0.64	0.63		
2nd Zn conc.	0.65	0.82	1.14	1.37	1.54	1.60	1.56	1.56	1.56		
Plant tailings	65.11	60.55	57.98	54.01	52.02	46.68	41.86	39.58	39.23		
August 1979											
Mill feed	100	100	100	100	100	100	100	100	100	100	
Pb conc.	22.13	13.33	25.96	29.79	36.04	45.62	50.63	58.92	58.71	59.63	
Cu conc.	0.90	2.39	3.95	3.96	3.25	2.34	1.60	1.34	1.10	1.11	
Bulk conc.	10.64	6.39	3.82	5.69	6.02	7.68	7.75	6.51	6.34	6.19	
Zn conc.	7.11	4.26	5.09	11.75	10.84	15.22	12.70	11.58	9.55	9.33	
2nd Zn conc.	4.54	7.56	10.18	6.78	5.55	4.26	2.65	2.01	1.64	1.60	
Plant tailings	54.68	66.07	50.99	42.03	38.30	24.87	24.66	19.65	22.66	22.15	



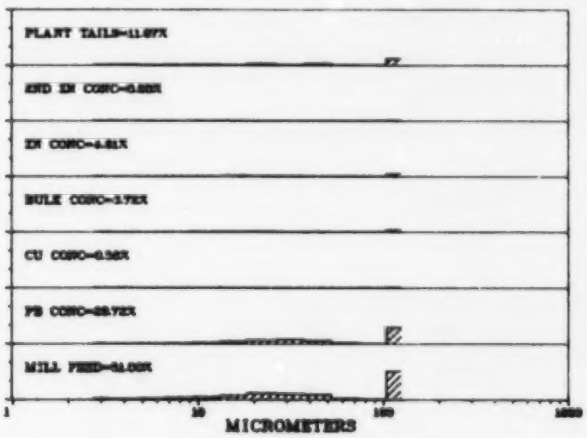
FREE GALENA, SEPTEMBER,1977



UNLIBERATED GALENA, SEPTEMBER,1977



FREE GALENA, AUGUST,1979



UNLIBERATED GALENA, AUGUST,1979

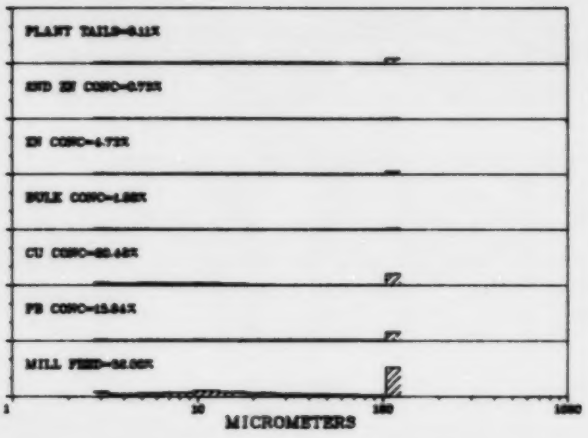
Fig. 8 - Recoveries for galena, as in caption to Fig. 7.

Table 14 - Balanced recoveries, free chalcopyrite (free chalcopyrite = 100%)

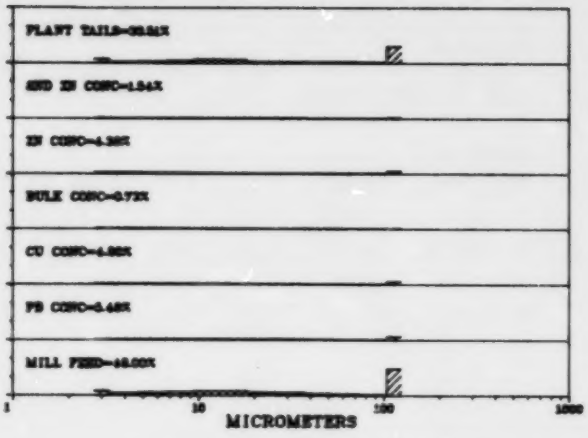
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
September 1977											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	2.34	3.79	2.85	2.82	2.57	2.68	2.81	3.02	3.27	3.47	3.68
Cu conc.	43.56	49.93	54.80	52.97	46.49	42.56	38.91	36.84	34.97	34.17	34.09
Bulk conc.	11.09	11.66	10.42	7.95	5.60	4.57	4.02	3.73	3.55	3.41	3.40
Zn conc.	33.64	27.00	24.71	27.70	35.30	38.23	41.03	42.12	42.40	42.19	42.10
2nd Zn conc.	1.82	1.53	1.58	2.01	1.80	1.73	1.53	1.43	1.36	1.31	1.31
Plant tailings	7.55	7.49	5.65	6.55	8.26	10.22	11.71	12.86	14.45	15.46	15.43
August 1979											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	46.66	40.42	23.06	18.14	21.82	24.99	29.98	30.61	29.84	29.09	28.74
Cu conc.	0.35	0.12	9.51	15.48	21.89	32.82	30.54	33.47	36.12	37.57	38.26
Bulk conc.	6.38	9.50	9.29	10.28	6.45	4.47	3.35	2.84	2.70	2.64	2.62
Zn conc.	7.04	20.79	31.77	23.76	24.22	20.28	16.30	13.91	13.18	12.90	12.76
2nd Zn conc.	4.06	7.86	11.14	7.34	2.65	1.64	1.23	1.04	0.99	0.97	0.96
Plant tailings	35.51	21.31	15.24	25.00	22.97	15.81	18.60	18.12	17.18	16.82	16.65

Table 15 - Balanced recoveries, unliberated chalcopyrite (unliberated chalcopyrite = 100%)

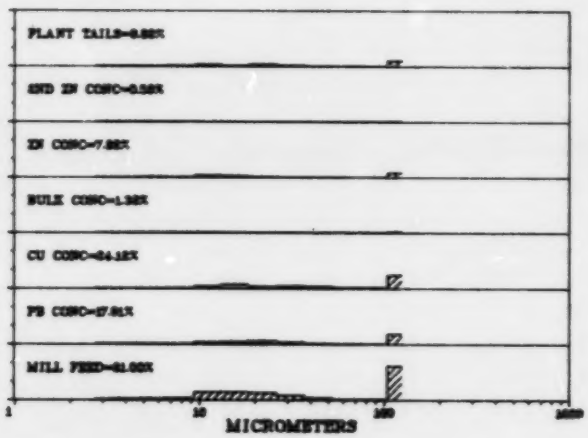
Flotation cells	Micrometres										
	<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
September 1977											
Mill feed	100	100	100	100	100	100	100	100	100	100	100
Pb conc.	10.47	11.83	17.47	22.00	24.33	26.80	30.36	33.26	32.73	32.01	31.64
Cu conc.	7.79	9.80	9.36	9.08	9.34	8.74	8.71	8.43	8.10	7.91	7.80
Bulk conc.	0.34	0.48	0.54	0.46	0.35	0.28	0.25	0.22	0.21	0.21	0.21
Zn conc.	21.45	30.32	29.06	25.51	19.94	16.28	14.32	12.92	12.48	12.16	12.03
2nd Zn conc.	2.71	1.90	1.59	1.40	1.08	1.32	2.48	2.98	2.68	2.79	2.75
Plant tailings	57.24	45.67	41.44	41.54	44.95	46.58	43.89	42.21	43.65	44.93	45.57
August 1979											
Mill feed	100	100	100	100	100	100	100	100	100		
Pb conc.	0.18	2.28	14.04	19.63	16.82	16.19	15.93	15.82	15.79		
Cu conc.	0.04	0.02	0.60	0.94	1.82	2.54	3.11	3.71	3.68		
Bulk conc.	1.98	4.07	4.56	2.64	2.80	2.62	2.43	2.41	2.39		
Zn conc.	47.85	29.81	27.08	15.93	12.19	10.08	9.38	9.31	9.24		
2nd Zn conc.	1.71	3.77	4.14	1.51	1.02	0.84	0.78	0.77	0.76		
Plant tailings	48.24	60.04	49.57	59.33	65.35	67.43	68.36	67.97	68.14		



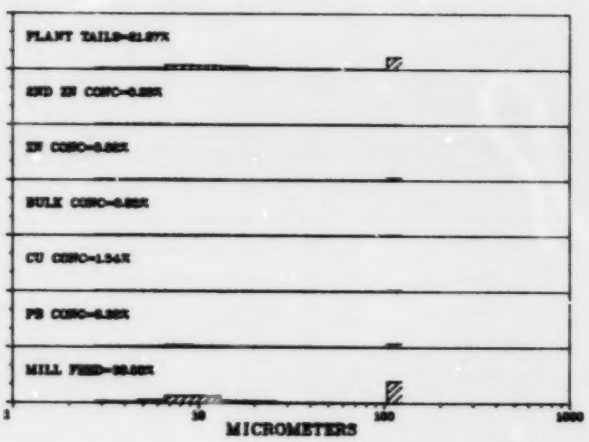
FREE CHALCOPYRITE, SEPTEMBER,1977



UNLIBERATED CHALCOPYRITE, SEPTEMBER,1977



FREE CHALCOPYRITE, AUGUST,1979



UNLIBERATED CHALCOPYRITE, AUGUST,1979

Fig. 9 - Recoveries for chalcopyrite, as in caption to Fig. 7.

Table 16 - Balanced recoveries[a], free sphalerite (total sphalerite = 100%)

Flotation cells		Micrometres										
		<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
August 1977												
Mill feed	61.00%	6.71	4.27	5.49	10.37	7.93	10.37	7.93	6.10	0.61	1.22	
Pb conc.	1.32%	0.35	0.12	0.13	0.13	0.13	0.13	0.13	0.12	0.07	0.01	
Cu conc.	0.40%	0.19	0.06	0.04	0.03	0.01	0.02	0.02	0.02	0.01		
Bulk conc.	2.00%	0.30	0.28	0.32	0.34	0.36	0.34	0.06				
Zn conc.	54.45%	5.50	3.58	4.86	9.36	6.95	9.40	7.21	5.85	0.53	1.21	
Plant tailings	2.83%	0.37	0.23	0.14	0.51	0.48	0.48	0.51	0.11			
September 1977												
Mill feed	65.00%	11.05	4.55	6.50	7.15	7.15	7.80	7.15	7.15	5.20	1.30	
Pb conc.	3.11%	0.25	0.56	0.86	0.56	0.16	0.25	0.06	0.19	0.16	0.06	
Cu conc.	0.17%	0.174	0.005	0.002	0.002	0.001						
Bulk conc.	1.74%	0.39	0.28	0.25	0.25	0.25	0.17	0.12	0.03			
Zn conc.	55.47%	9.38	3.31	4.96	6.01	6.31	6.95	6.50	6.39	4.55	1.11	
2nd Zn conc.	2.27%	0.32	0.20	0.23	0.20	0.23	0.23	0.27	0.27	0.27	0.05	
Plant tailings	2.24%	0.54	0.20	0.20	0.13	0.20	0.20	0.20	0.27	0.22	0.08	
August 1979												
Mill feed	61.00%	0.61	1.83	4.27	4.88	5.49	5.49	7.32	8.54	7.93	6.71	7.93
Pb conc.	2.92%	0.09	0.44	0.34	0.21	0.23	0.25	0.28	0.23	0.16	0.69	
Cu conc.	0.03%	0.002	0.014	0.011	0.005	0.002	0.001	0.001				
Bulk conc.	1.61%	0.01	0.10	0.11	0.23	0.28	0.29	0.26	0.23	0.08	0.01	0.01
Zn conc.	48.63%	0.35	0.75	3.00	3.93	4.54	4.12	5.86	7.20	6.46	4.95	7.47
2nd Zn conc.	3.62%	0.04	0.07	0.18	0.33	0.44	0.54	0.66	0.63	0.48	0.18	0.07
Plant tailings	4.19%	0.12	0.46	0.63	0.18	0.00	0.29	0.25	0.25	0.75	0.88	0.38

[a]Balanced recoveries assuming weight per cent of free plus unliberated sphalerite in mill feed = 100%.

Table 17 - Balanced recoveries*, unliberated sphalerite (total sphalerite = 100%)

Flotation cells		Micrometres										
		<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.0	>74
August 1977												
Mill feed	39.00%	7.27	2.59	1.42	2.15	2.59	4.54	5.32	6.49	4.15	1.84	0.64
Pb conc.	5.38%	0.54	0.22	0.22	0.27	0.48	0.91	0.91	0.97	0.86		
Cu conc.	0.40%	0.25	0.02	0.02	0.03	0.02	0.02	0.03	0.01			
Bulk conc.	1.85%	0.09	0.15	0.17	0.22	0.39	0.20	0.43	0.20			
Zn conc.	19.81%	3.89	1.06	0.33	1.18	0.79	2.73	2.93	4.40	2.50		
Plant tailings	11.56%	2.50	1.14	0.68	0.45	0.91	0.68	1.02	0.91	0.79	1.84	0.64
September 1977												
Mill feed	35.00%	1.05	1.75	1.75	1.75	2.80	5.95	5.25	5.25	4.55	2.80	2.10
Pb conc.	3.64%	0.22	0.18	0.29	0.18	0.18	0.22	0.33	0.54	0.73	0.55	0.22
Cu conc.	0.07%	0.001	0.00	0.008	0.018	0.019	0.011	0.006	0.001			
Bulk conc.	1.67%	0.10	0.05	0.10	0.15	0.25	0.32	0.25	0.27	0.18		
Zn conc.	21.10%	0.24	0.60	0.46	0.72	1.15	4.48	3.54	3.26	2.98	1.92	1.75
2nd Zn conc.	1.34%	0.03	0.01	0.04	0.09	0.09	0.20	0.27	0.27	0.27	0.07	
Plant tailings	7.18%	0.46	0.91	0.85	0.59	1.11	0.72	0.85	0.91	0.39	0.26	0.13
August 1979												
Mill feed	39.00%	0.39	0.78	1.17	0.39	2.34	2.34	5.07	5.85	7.41	7.02	6.24
Pb conc.	3.00%	0.06	0.21	0.33	0.24	0.21	0.30	0.36	0.54	0.36	0.33	0.06
Cu conc.	0.03%	0.002	0.009	0.010	0.007	0.003	0.002	0.003	0.002	0.002		
Bulk conc.	1.47%	0.01	0.01	0.03	0.07	0.10	0.18	0.27	0.39	0.27	0.10	0.04
Zn conc.	24.45%	0.22	0.19	0.21	0.04	1.21	1.33	3.74	4.45	4.48	4.73	3.85
2nd Zn conc.	1.58%	0.02	0.02	0.00	0.03	0.06	0.11	0.19	0.30	0.35	0.33	0.17
Plant tailings	8.47%	0.08	0.34	0.59	0.00	0.76	0.42	0.51	0.17	1.95	1.53	2.12

*Balanced recoveries assuming weight per cent of free plus unliberated sphalerite in mill feed = 100%.

Table 18 - Balanced recoveries[a], free galena (total galena = 100%)

Flotation cells		Micrometres								
		<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	>74
September 1977										
Mill feed	36.00%	8.28	2.88	3.96	4.32	4.32	3.96	3.60	3.96	0.72
Pb conc.	31.39%	5.13	2.53	3.64	3.88	4.06	3.87	3.60	3.96	0.72
Cu conc.	1.30%	0.68	0.17	0.17	0.18	0.09	0.01			
Bulk conc.	0.22%	0.08	0.03	0.03	0.03	0.03	0.02			
Zn conc.	1.35%	1.00	0.06	0.08	0.15	0.06				
2nd Zn conc.	0.17%	0.008	0.010	0.032	0.062	0.051	0.007			
Plant tailings	1.57%	1.38	0.08	0.010	0.02	0.03	0.05			
August 1979										
Mill feed	49.00%	0.98	0.49	1.47	3.92	5.88	11.76	10.78	7.35	6.37
Pb conc.	29.43%	0.18	0.21	1.18	2.40	2.70	4.69	5.90	6.71	5.46
Cu conc.	0.14	0.006	0.034	0.051	0.024	0.018	0.004	0.004	0.007	0.00
Bulk conc.	2.47	0.02	0.00	0.07	0.10	0.40	0.47	0.54	0.42	0.45
Zn conc.	4.30	0.13	0.00	0.17	1.02	1.24	1.54	0.04	0.08	0.08
2nd Zn conc.	0.01	0.007	0.00							
Plant tailings	12.65	0.63	0.25	0.00	0.38	1.52	5.06	4.30	0.13	0.38

[a]Balanced recoveries assuming weight per cent of free plus unliberated galena in mill feed = 100%.

Table 19 - Balanced recoveries[a], unliberated galena (total galena = 100%)

Flotation cells		Micrometres									
		<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	>74
September 1977											
Mill feed	64.00%	19.2	3.84	4.48	5.12	5.12	7.68	9.60	7.68	1.28	
Pb conc.	29.89%	3.85	0.96	1.52	2.37	2.31	4.87	7.45	5.51	1.05	
Cu conc.	0.14%	0.07	0.02	0.02	0.02	0.01					
Bulk conc.	4.15%	1.12	0.71	0.58	0.58	0.58	0.58				
Zn conc.	7.01%	3.30	0.56	0.49	0.49	0.56	0.56	0.49	0.56		
2nd Zn conc.	0.92%	0.12	0.06	0.12	0.13	0.14	0.13	0.08	0.01		
Plant tailings	21.89%	10.74	1.53	1.75	1.53	1.53	1.53	1.53	0.22		
August 1979											
Mill feed	51.00%	1.53	0.51	2.04	3.06	4.59	7.14	11.73	10.2	8.67	1.53
Pb conc.	29.58%	0.51	0.00	1.00	0.38	2.24	4.15	6.56	8.57	4.75	1.34
Cu conc.	0.56	0.01	0.04	0.10	0.13	0.10	0.06	0.05	0.05	0.00	0.02
Bulk conc.	3.74	0.15	0.00	0.04	0.30	0.37	0.86	1.08	0.34	0.60	
Zn conc.	4.81	0.10	0.00	0.10	0.67	0.38	1.68	1.01	0.77	0.05	0.05
2nd Zn conc.	0.82	0.06	0.10	0.22	0.18	0.10	0.16				
Plant tailings	11.57	0.70	0.34	0.58	1.40	1.40	0.23	3.03	0.47	3.27	0.12

[a]Balanced recoveries assuming weight per cent of free plus unliberated galena in mill feed = 100%.

Table 20 - Balanced recoveries*, free chalcopyrite (total chalcopyrite = 100%)

Flotation cells		Micrometres										
		<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.4	>74.4
September 1977												
Mill feed	52.00%	7.28	3.12	5.20	6.24	9.88	7.28	5.20	3.12	2.60	1.56	0.52
Pb conc.	13.47%	1.41	0.62	1.72	1.25	1.72	1.72	1.72	1.56	0.77	0.46	0.52
Cu conc.	22.08%	3.73	1.63	2.63	3.56	5.54	3.10	1.10	.38	0.41		
Bulk conc.	1.87%	0.84	0.47	0.43	0.11	0.02						
Zn conc.	4.72%	0.52	0.09	0.24	0.47	1.09	0.80	1.09	0.09	0.14	0.19	
2nd Zn conc.	0.74%	0.14	0.04	0.09	0.21	0.14	0.11	0.01				
Plant tailings	9.12%	0.64	0.27	0.09	0.64	1.37	1.55	1.28	1.09	1.28	0.91	
August 1979												
Mill feed	61.00%	0.61	1.83	2.44	3.05	14.03	14.03	12.20	7.93	3.05	0.61	1.22
Pb conc.	17.69%	0.14	0.54	0.18	0.36	3.58	4.12	5.55	2.86	0.36		
Cu conc.	23.81%	0.24	0.42	0.39	0.85	3.28	7.21	2.82	4.08	2.69	0.61	1.22
Bulk conc.	1.38%	0.04	0.14	0.21	0.30	0.55	0.14					
Zn conc.	7.87%	0.08	0.39	1.10	0.32	3.54	1.97	0.47				
2nd Zn conc.	0.59%	0.03	0.14	0.36	0.04	0.02						
Plant tailings	9.66%	0.08	0.20	0.20	1.18	3.06	0.59	3.36	0.99			

*Balanced recoveries assuming weight per cent of free plus unliberated chalcopyrite in mill feed = 100%.

Table 21 - Balanced recoveries*, unliberated chalcopyrite (total chalcopyrite = 100%)

Flotation cells		Micrometres										
		<3.3	4.7	6.6	9.4	13.2	18.6	26.3	37.1	52.4	74.4	>74.4
September 1977												
Mill feed	48.00%	7.20	2.88	4.80	5.76	7.20	7.20	4.80	4.32	1.92	1.44	0.48
Pb conc.	5.47%	0.27	0.16	0.49	0.71	0.82	0.93	0.99	0.99	0.11		
Cu conc.	7.91%	0.72	0.58	1.24	0.85	0.96	0.81	1.63	1.12			
Bulk conc.	0.73%	0.18	0.18	0.23	0.12	0.02						
Zn conc.	4.36%	1.17	1.18	0.96	0.66	0.26	0.09	0.04				
2nd Zn conc.	1.54%	0.23	0.00	0.05	0.06	0.02	0.18	0.62	0.38			
Plant tailings	27.99%	4.63	0.78	1.83	3.36	5.12	5.19	1.52	1.83	1.81	1.44	0.48
August 1979												
Mill feed	39.00%	1.56	1.17	4.68	12.48	12.48	3.12	2.73	0.43	0.35		
Pb conc.	6.69%	0.00	0.06	1.01	2.89	1.07	0.82	0.78	0.06			
Cu conc.	7.86%	0.13	0.13	0.34	1.13	5.03	0.40	0.42	0.15	0.13		
Bulk conc.	0.84%	0.02	0.08	0.19	0.18	0.27	0.10					
Zn conc.	3.88%	0.73	0.16	1.20	1.28	0.43	0.08					
2nd Zn conc.	0.29%	0.02	0.08	0.19								
Plant tailings	19.44%	0.66	0.66	1.75	7.00	5.68	1.72	1.53	0.22	0.22		

*Balanced recoveries assuming weight per cent of free plus unliberated chalcopyrite in mill feed = 100%.

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